



1. (currently amended)

A method for optimizing a wireless electromagnetic communications network, comprising:

a wireless electromagnetic communications network, comprising

a set of nodes, said set of nodes further comprising,

at least a first subset wherein each node is MIMO-capable,

comprising:

an antennae array of M antennae, where $M \geq$ one,

a transceiver for each antenna in said spatially diverse

antennae array,

means for digital signal processing to convert analog radio

signals into digital signals and digital signals into analog

radio signals,

means for coding and decoding data, symbols, and control

information into and from digital signals,

diversity capability means for transmission and reception of

said analog radio waves[signals],

and,

means for input and output from and to a non-radio

interface for digital signals;

said set of nodes being deployed according to design rules that prefer meeting the following criteria:

said set of nodes further comprising two or more proper subsets of nodes, with a first proper subset being the transmit uplink / receive downlink set, and a second proper subset being the transmit downlink / receive uplink set;

each node in said set of nodes belonging to no more transmitting uplink or receiving uplink subsets than it has diversity capability means;

each node in a transmit uplink / receive downlink subset has no more nodes with which it will hold time and frequency coincident

communications in its field of view, than it has diversity capability;
each node in a transmit downlink / receive uplink subset has no more nodes with which it will hold time and frequency coincident communications in its field of view, than it has diversity capability;
each member of a transmit uplink / receive downlink subset cannot hold time and frequency coincident communications with any other member of that transmit uplink / receive downlink subset;
and,
each member of a transmit downlink / receive uplink subset cannot hold time and frequency coincident communications with any other member of that transmit downlink / receive uplink subset;
transmitting, in said wireless electromagnetic communications network, independent information from each node belonging to a first proper subset, to one or more receiving nodes belonging to a second proper subset that are viewable from the transmitting node;
processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset, information transmitted from one or more nodes belonging to said first proper subset;
and,
dynamically adapting the diversity channels[capability means] and said proper subsets to optimize said network.

2. (currently amended) A method for optimizing a wireless electromagnetic communications network, comprising:
a wireless electromagnetic communications network, comprising
a set of nodes, said set of nodes further comprising,

at least a first subset wherein each node is MIMO-capable,
comprising:
a spatially diverse antennae array of M antennae, where M
 \geq two,
a transceiver for each antenna in said spatially diverse
antennae array,
means for digital signal processing to convert analog radio
signals into digital signals and digital signals into analog
radio signals,
means for coding and decoding data, symbols, and control
information into and from digital signals,
diversity capability means for transmission and reception of
said analog radio waves[signals],
and,
means for input and output from and to a non-radio
interface for digital signals;
said set of nodes being deployed according to design rules that prefer
meeting the following criteria:
said set of nodes further comprising two or more proper subsets of
nodes, with a first proper subset being the transmit uplink / receive
downlink set, and a second proper subset being the transmit
downlink / receive uplink set;
each node in said set of nodes belonging to no more transmitting
uplink or receiving uplink subsets than it has diversity capability
means;
each node in a transmit uplink / receive downlink subset has no
more nodes with which it will hold time and frequency coincident
communications in its field of view, than it has diversity
capability;
each node in a transmit downlink / receive uplink subset has no
more nodes with which it will hold time and frequency coincident

92 communications in its field of view, than it has diversity
93 capability;
94 each member of a transmit uplink / receive downlink subset cannot
95 hold time and frequency coincident communications with any
96 other member of that transmit uplink / receive downlink subset;
97 and,
98 each member of a transmit downlink / receive uplink subset cannot
99 hold time and frequency coincident communications with any
100 other member of that transmit downlink / receive uplink subset;
101 transmitting, in said wireless electromagnetic communications network,
102 independent information from each node belonging to a first proper subset, to one
103 or more receiving nodes belonging to a second proper subset that are viewable
104 from the transmitting node;
105 processing independently, in said wireless electromagnetic communications
106 network, at each receiving node belonging to said second proper subset,
107 information transmitted from one or more nodes belonging to said first proper
108 subset;
109 and,
110 dynamically adapting the diversity ~~channels~~ [capability means] and said proper
111 subsets to optimize said network.
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113
114 3. (original) A method as in claim 1, wherein dynamically adapting the diversity
115 channels and said proper subsets to optimize said network further comprises:
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117 using substantive null steering to minimize SINR between nodes transmitting and
118 receiving information.
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120 4. (original) A method as in claim 1, wherein dynamically adapting the diversity
121 channels and said proper subsets to optimize said network further comprises:
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123 using max-SINR null- and beam-steering to minimize intra-network interference.

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125 5. (original) A method as in claim 1, wherein dynamically adapting the diversity
126 channels and said proper subsets to optimize said network further comprises:

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128 using MMSE null- and beam-steering to minimize intra-network interference.

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131 6. (original) A method as in claim 1, wherein dynamically adapting the diversity
132 channels and said proper subsets to optimize said network further comprises:

133
134 designing the network such that reciprocal symmetry exists for each pairing of
135 uplink receive and downlink receive proper subsets.

136
137 7. (original) A method as in claim 1, wherein dynamically adapting the diversity
138 channels and said proper subsets to optimize said network further comprises:

139
140 designing the network such that substantial reciprocal symmetry exists for each
141 pairing of uplink receive and downlink receive proper subsets.

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143 8. (original) A method as in claim 1, wherein the network uses TDD communication
144 protocols.

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146 9. (original) A method as in claim 1, wherein the network uses FDD communication
147 protocols.

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149 10. (original) A method as in claim 3, wherein the network uses simplex communication
150 protocols.

11. (original) A method as in claim 1, wherein the network uses random access packets, and receive and transmit operations are all carried out on the same frequency channels for each link.

12. (original) A method as in claim 1, wherein dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises

if the received interference is spatially white in both link directions, setting

$g_1(a) \propto w_2^* q$ and $g_2(q) \propto w_1^*(q)$ at both ends of the link, where

$\{g_2(q), w_1(q)\}$ are the linear transmit and receive weights used in the downlink;

but if the received interference is not spatially white in both link directions, constraining $\{g_1(q)\}$ and $\{g_2(q)\}$ to preferentially satisfy:

$$\sum_{q=1}^{Q_{21}} g_1^T(q) R_{i1i1}[n_1(q)] g_1^*(q) = \sum_{n=1}^{N_1} \text{Tr}\{R_{i1,i1}(n)\} = M_1 R_1$$

$$\sum_{q=1}^{Q_{12}} g_2^T(q) R_{i2i2}[n_2(q)] g_2^*(q) = \sum_{n=1}^{N_2} \text{Tr}\{R_{i2,i2}(n)\} = M_2 R_2.$$

13. (original) A method as in claim 1, wherein:

a proper subset may incorporate one or more nodes that are in a receive-only mode for every diversity channel.

14. (original) A method as in claim 1, wherein:

the network may dynamically reassign a node from one proper subset to another.

15. (original) A method as in claim 1, wherein:

the network may dynamically reassign a proper subset of nodes from one proper subset to another.

16. (original) A method as in claim 7, wherein the step of designing the network such that substantial reciprocal symmetry exists for the uplink and downlink channels further comprises:

if the received interference is spatially white in both link directions, setting

$g_1(a) \propto w_2^* q$ and $g_2(q) \propto w_1^*(q)$ at both ends of the link, where

$\{g_2(q), w_1(q)\}$ are the linear transmit and receive weights used in the downlink;

but if the received interference is not spatially white in both link directions, constraining $\{g_1(q)\}$ and $\{g_2(q)\}$ to preferentially satisfy:

$$\sum_{Q_{21}} g_1^T(q) R_{i1i1} [n_1(q)] g_1^*(q) = \sum_{N_1} \text{Tr}\{R_{i1i1}(n)\} = M_1 R_1$$

$$\sum_{q=1}^{Q_{12}} g_2^T(q) R_{i_2 i_2} [n_2(q)] g_2^*(q) = \sum_{n=1}^{N_2} \text{Tr} \{ R_{i_2 i_2}(n) \} = M_2 R_2.$$

17. (original) A method as in claim 1, wherein the means for digital signal processing in said first subset of MIMO-capable nodes further comprises:

- an ADC bank for downconversion of received RF signals into digital signals;
- a MT DEMOD element for multitone demodulation, separating the received signal into distinct tones and splitting them into 1 through K_{feed} FDMA channels, said separated tones in aggregate forming the entire baseband for the transmission, said MT DEMOD element further comprising
 - a Comb element with a multiple of 2 filter capable of operating on a 128-bit sample; and,
 - an FFT element with a 1,024 real-IF function;
- a Mapping element for mapping the demodulated multitone signals into a 426 active receive bins, wherein
 - each bin covers a bandwidth of 5.75MHz;
 - each bin has an inner passband of 4.26MHz for a content envelope;
 - each bin has an external buffer, up and down, of 745kHz;
 - each bin has 13 channels, CH0 through CH12, each channel having 320 kHz and 32 tones, T0 through T31, each tone being 10kHz, with the inner 30 tones being used information bearing and T0 and T31 being reserved;

each signal being 100μs, with 12.5μs at each end thereof at the front and rear end thereof forming respectively a cyclic prefix and cyclic suffix buffer to punctuate successive signals;

and,
a symbol-decoding element for interpretation of the symbols embedded in the signal.

18. (original) A method as in claim 1, wherein dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises

using at each node the receive combiner weights as transmit distribution weights during subsequent transmission operations, so that the network is preferentially designed and constrained such that each link is substantially reciprocal, such that the ad hoc network capacity measure can be made equal in both link directions by setting at both ends of the link:

$$g_2(q) \propto w_2^*(k,q) \text{ and } g_1(k,q) \propto w_1^*(k,q),$$

where $\{g_2(k,q), w_1(k,q)\}$ are the linear transmit and receive weights to transmit data $d_2(k,q)$ from node $n_2(q)$ to node $n_1(q)$ over channel k in the downlink, and where $\{g_1(k,q), w_2(k,q)\}$ are the linear transmit and receive weights used to transmit data $d_1(k,q)$ from node $n_1(q)$ back to node $n_2(q)$ over equivalent channel k in the uplink.

263
264 19. (original) A method as in claim 1, wherein the step of each node in a transmit
265 downlink / receive uplink subset having no more nodes with which it will hold time and
266 frequency coincident communications in its field of view, than it has diversity capability
267 further comprises:

268
269 designing the topological, physical layout of nodes to enforce this constraint
270 within the node's diversity channel means limitations.
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274 20. (original) A method as in claim 1, wherein the step of each node in a transmit uplink
275 / receive downlink subset having no more nodes with which it will hold time and
276 frequency coincident communications in its field of view, than it has diversity capability
277 further comprises:

278
279 designing the topological, physical layout of nodes to enforce this constraint
280 within the node's diversity channel means limitations.
281
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283 21. (original) A method as in claim 1, wherein the step of dynamically adapting the
284 diversity channels and said proper subsets to optimize said network further comprises:

285
286 allowing a proper subset to send redundant data transmissions over multiple
287 frequency channels to another proper subset.
288

289 22. (original) A method as in claim 1, wherein the step of dynamically adapting the
290 diversity channels and said proper subsets to optimize said network further comprises:

291
292 allowing a proper subset to send redundant data transmissions over multiple
293 simultaneous or differential time slots to another proper subset.

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296 23. (original) A method as in claim 1, wherein said transmitting proper subset and
297 receiving proper subset diversity capability means for transmission and reception of said
298 analog radio waves further comprise:

299

300 spatial diversity of antennae.

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302

303 24. (original) A method as in claim 1, wherein said transmitting proper subset and
304 receiving proper subset diversity capability means for transmission and reception of said
305 analog radio waves further comprise:

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307 polarization diversity of antennae.

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310 25. (original) A method as in claim 1, wherein said transmitting proper subset and
311 receiving proper subset diversity capability means for transmission and reception of said
312 analog radio waves further comprise:

313

314 any combination of temporal, spatial, and polarization diversity of antennae.

315

316

317 26. (original) A method as in claim 1, wherein the step of dynamically adapting the
318 diversity channels and said proper subsets to optimize said network further comprises:

319

320 incorporating network control and feedback aspects as part of the signal encoding
321 process.

322

323 27. (original) A method as in claim 1, wherein the step of dynamically adapting the
324 diversity channels and said proper subsets to optimize said network further comprises:

325
326 incorporating network control and feedback aspects as part of the signal encoding
327 process and including said as network information in one direction of the
328 signalling and optimization process, using the perceived environmental
329 condition's effect upon the signals in the other direction of the signalling and
330 optimization process.

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332
333 28. (original) A method as in claim 1, wherein the step of dynamically adapting the
334 diversity channels and said proper subsets to optimize said network further comprises:

335
336 adjusting the diversity channel use between any proper sets of nodes by rerouting
337 any active link based on perceived unacceptable SINR experienced on that active
338 link and the existence of an alternative available link using said adjusted diversity
339 channel.

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342 29. (original) A method as in claim 1, wherein the step of dynamically adapting the
343 diversity channels and said proper subsets to optimize said network further comprises:

344
345 switching a particular node from one proper subset to another due to changes in
346 the external environment affecting links between that node and other nodes in the
347 network.

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350 30. (original) A method as in claim 1, wherein the step of dynamically adapting the
351 diversity channels and said proper subsets to optimize said network further comprises:

352
353 dynamically reshuffling proper subsets to more closely attain network objectives
354 by taking advantage of diversity channel availability.

31. (original) A method as in claim 1, wherein the step of dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

dynamically reshuffling proper subsets to more closely attain network objectives by accounting for node changes.

32. (original) A method as in claim 31, wherein said node changes include any of:

adding diversity capability to a node, adding a new node within the field of view of another node, removing a node from the network (temporarily or permanently), or losing diversity capability at a node.

33. (original) A method as in claim 1, wherein the step of dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

suppressing unintended recipients or transmitters by the imposition of signal masking.

34. (original) A method as in claim 33, wherein the step of suppressing unintended recipients or transmitters by the imposition of signal masking further comprises:

imposition of an origination mask.

34. (original) A method as in claim 33, wherein the step of suppressing unintended recipients or transmitters by the imposition of signal masking further comprises:

imposition of a recipient mask.

35. (original) A method as in claim 33, wherein the step of suppressing unintended recipients or transmitters by the imposition of signal masking further comprises:

387
388 imposition of any combination of origination and recipient masks.

389
390 36. (original) A method as in claim 33, wherein the step of dynamically adapting the
391 diversity channels and said proper subsets to optimize said network further comprises:

392
393 using signal masking to secure transmissions against unintentional, interim
394 interception and decryption by the imposition of a signal mask at origination, the
395 transmission through any number of intermediate nodes lacking said signal mask,
396 and the reception at the desired recipient which possesses the correct means for
397 removal of the signal mask.

398
399 37. (original) A method as in claim 36, wherein the signal masking is shared by a proper
400 subset.

401
402 38. (original) A method as in claim 1, wherein the step of dynamically adapting the
403 diversity channels and said proper subsets to optimize said network further comprises:

404
405 heterogenous combination of a hierarchy of proper subsets, one within the other,
406 each paired with a separable subset wherein the first is a transmit uplink and the
407 second is a transmit downlink subset, such that the first subset of each pair of
408 subsets is capable of communication with the members of the second subset of
409 each pair, yet neither subset may communicate between its own members.

410
411 39. (original) A method as in claim 1, wherein the step of dynamically adapting the
412 diversity channels and said proper subsets to optimize said network further comprises:

413
414 using as many of the available diversity channels as are needed for traffic between
415 any two nodes from 1 to NumChannels, where NumChannels equals the maximal
416 diversity capability between said two nodes.

40. (original) A method as in claim 1, wherein the step of dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

using a water-filling algorithm to route traffic between an origination and destination node through any intermediate subset of nodes that has available diversity channel capacity.

41. (original) A method for optimizing a wireless electromagnetic communications network, comprising:

a wireless electromagnetic communications network, comprising

a set of nodes, said set further comprising,

at least a first subset of MIMO-capable nodes, each MIMO-capable node comprising:

a spatially diverse antennae array of M antennae, where $M \geq$ two, said antennae array being polarization diverse, and circularly symmetric, and providing 1-to-M RF feeds; a transceiver for each antenna in said array, said transceiver further comprising

a Butler Mode Forming element, providing spatial signature separation with a FFT-LS algorithm, reciprocally forming a transmission with shared receiver feeds, such that the number of modes out equals the numbers of antennae, establishing such as an ordered set with decreasing energy, further comprising:

a dual-polarization element for splitting the modes into positive and negative polarities with opposite and orthogonal polarizations, that can work with circular polarizations,

449 and
 450 a dual-polarized link CODEC;
 451 a transmission/reception switch comprising,
 452 a vector OFDM receiver element;
 453 a vector OFDM transmitter element;
 454 a LNA bank for a receive signal, said LNA
 455 Bank also instantiating low noise
 456 characteristics for a transmit signal;
 457 a PA bank for the transmit signal that
 458 receives the low noise characteristics for
 459 said transmit signal from said LNA bank;
 460 an AGC for said LNA bank and PA bank;
 461 a controller element for said
 462 transmission/reception switch enabling
 463 baseband link distribution of the energy over
 464 the multiple RF feeds on each channel to
 465 steer up to K_{feed} beams and nulls
 466 independently on each FDMA channel;
 467 a Frequency Translator;
 468 a timing synchronization element controlling
 469 said controller element;
 470 further comprising a system clock,
 471 a universal Time signal element;
 472 GPS;
 473 a multimode power management element
 474 and algorithm;
 475 and,
 476 a LOs element;
 477 said vector OFDM receiver element comprising
 478 an ADC bank for downconversion of
 479 received RF signals into digital signals;

480 a MT DEMOD element for multitone
 481 demodulation, separating the received signal
 482 into distinct tones and splitting them into 1
 483 through K_{feed} FDMA channels, said
 484 separated tones in aggregate forming the
 485 entire baseband for the transmission, said
 486 MT DEMOD element further comprising
 487 a Comb element with a multiple of 2
 488 filter capable of operating on a 128-
 489 bit sample; and,
 490 an FFT element with a 1,024 real-IF
 491 function;
 492 a Mapping element for mapping the
 493 demodulated multitone signals into a 426
 494 active receive bins, wherein
 495 each bin covers a bandwidth of
 496 5.75MHz;
 497 each bin has an inner passband of
 498 4.26MHz for a content envelope;
 499 each bin has an external buffer, up
 500 and down, of 745kHz;
 501 each bin has 13 channels, CH0
 502 through CH12, each channel having
 503 320 kHz and 32 tones, T0 through
 504 T31, each tone being 10kHz, with
 505 the inner 30 tones being used
 506 information bearing and T0 and T31
 507 being reserved;
 508 each signal being 100 μ s, with 12.5 μ s
 509 at each end thereof at the front and
 510 rear end thereof forming respectively

511 a cyclic prefix and cyclic suffix
 512 buffer to punctuate successive
 513 signals;
 514 a MUX element for timing modification
 515 capable of element-wise multiplication
 516 across the signal, which halves the number
 517 of bins and tones but repeats the signal for
 518 high-quality needs;
 519 a link CODEC, which separates each FDMA
 520 channel into 1 through M links, further
 521 comprising
 522 a SOVA bit recovery element;
 523 an error coding element;
 524 an error detection element;
 525 an ITI remove element;
 526 a tone equalization element;
 527 and,
 528 a package fragment retransmission
 529 element;
 530 a multilink diversity combining element,
 531 using a multilink Rx weight adaptation
 532 algorithm for Rx signal weights $W(k)$ to
 533 adapt transmission gains $G(k)$ for each
 534 channel k ;
 535 an equalization algorithm, taking the signal
 536 from said multilink diversity combining
 537 element and controlling a delay removal
 538 element;
 539 said delay removal element separating signal
 540 content from imposed pseudodelay and

541 experienced environmental signal delay, and
 542 passing the content-bearing signal to a
 543 symbol-decoding element;
 544 said symbol-decoding element for
 545 interpretation of the symbols embedded in
 546 the signal, further comprising:
 547 an element for delay gating;
 548 a QAM element; and
 549 a PSK element;
 550 said vector OFDM transmitter element comprising:
 551 a DAC bank for conversion of digital signals
 552 into RF signals for transmission;
 553 a MT MOD element for multitone
 554 modulation, combining and joining the
 555 signal to be transmitted from 1 through K_{feed}
 556 FDMA channels, said separated tones in
 557 aggregate forming the entire baseband for
 558 the transmission, said MT MOD element
 559 further comprising
 560 a Comb element with a multiple of 2
 561 filter capable of operating on a 128-
 562 bit sample; and,
 563 an IFFT element with a 1,024 real-IF
 564 function;
 565 a Mapping element for mapping the
 566 modulated multitone signals from 426
 567 active transmit bins, wherein
 568 each bin covers a bandwidth of
 569 5.75MHz;
 570 each bin has an inner passband of
 571 4.26MHz for a content envelope;

572 each bin has an external buffer, up
573 and down, of 745kHz;
574 each bin has 13 channels, CH0
575 through CH12, each channel having
576 320 kHz and 32 tones, T0 through
577 T31, each tone being 10kHz, with
578 the inner 30 tones being used
579 information bearing and T0 and T31
580 being reserved;
581 each signal being 100 μ s, with 12.5 μ s
582 at each end thereof at the front and
583 rear end thereof forming respectively
584 a cyclic prefix and cyclic suffix
585 buffer to punctuate successive
586 signals;
587 a MUX element for timing modification
588 capable of element-wise multiplication
589 across the signal, which halves the number
590 of bins and tones but repeats the signal for
591 high-quality needs;
592 a symbol-coding element for embedding the
593 symbols to be interpreted by the receiver in
594 the signal, further comprising:
595 an element for delay gating;
596 a QAM element; and
597 a PSK element;
598 a link CODEC, which aggregates each
599 FDMA channel from 1 through M links,
600 further comprising
601 a SOVA bit recovery element;
602 an error coding element;

603 an error detection element;
 604 an ITI remove element;
 605 a tone equalization element;
 606 and,
 607 a package fragment retransmission
 608 element;
 609 a multilink diversity distribution element,
 610 using a multilink Tx weight adaptation
 611 algorithm for Tx signal weights to adapt
 612 transmission gains $G(k)$ for each channel
 613 k , such that $g(q;k) \propto w^*(q;k)$;
 614
 615 a TCM codec;
 616 a pilot symbol CODEC element that integrates with said
 617 FFT-LS algorithm a link separation, a pilot and data signal
 618 elements sorting, a link detection, multilink combination,
 619 and equalizer weight calculation operations;
 620 means for diversity transmission and reception,
 621 and,
 622 means for input and output from and to a non-radio
 623 interface;
 624
 625 said set of nodes being deployed according to design rules that prefer
 626 meeting the following criteria:
 627
 628 said set of nodes further comprising two or more proper subsets of
 629 nodes, with a first proper subset being the transmit uplink / receive
 630 downlink set, and a second proper subset being the transmit
 631 downlink / receive uplink set;
 632

633 each node in said set of nodes belonging to no more transmitting
634 uplink or receiving uplink subsets than it has diversity capability
635 means;

636
637 each node in a transmit uplink / receive downlink subset has no
638 more nodes with which it will hold time and frequency coincident
639 communications in its field of view, than it has diversity
640 capability;

641
642 each node in a transmit downlink / receive uplink subset has no
643 more nodes with which it will hold time and frequency coincident
644 communications in its field of view, than it has diversity
645 capability;

646
647 each member of a transmit uplink / receive downlink subset cannot
648 hold time and frequency coincident communications with any
649 other member of that transmit uplink / receive downlink subset;

650
651 and,

652
653 each member of a transmit downlink / receive uplink subset cannot
654 hold time and frequency coincident communications with any
655 other member of that transmit downlink / receive uplink subset;

656
657 transmitting, in said wireless electromagnetic communications network,
658 independent information from each node belonging to a first proper subset, to one
659 or more receiving nodes belonging to a second proper subset that are viewable
660 from the transmitting node;

661
662 processing independently, in said wireless electromagnetic communications
663 network, at each receiving node belonging to said second proper subset,

information transmitted from one or more nodes belonging to said first proper subset;

and,

designing the network such that substantially reciprocal symmetry exists for the uplink and downlink channels by,

if the received interference is spatially white in both link directions, setting

$g_1(a) \propto w^*_2(q)$ and $g_2(q) \propto w^*_1(q)$ at both ends of the link,

where $\{g_2(q), w_1(q)\}$ are the linear transmit and receive weights used in the downlink;

but if the received interference is not spatially white in both link directions, constraining $\{g_1(q)\}$ and $\{g_2(q)\}$ to satisfy:

$$\sum_{q=1}^{Q_{21}} g_1^T(q) R_{i1i1} [n_1(q)] g^*_1(q) =$$

$$\sum_{n=1}^{N_1} \text{Tr}\{R_{i1i1}(n)\} = M_1 R_1$$

$$\sum_{q=1}^{Q_{12}} g_2^T(q) R_{i2i2} [n_2(q)] g^*_2(q) =$$

$$\sum_{n=1}^{N_2} \text{Tr}\{R_{i_2i_2}(n)\} = M_2 R_2,$$

using any standard communications protocol, including TDD, FDD, simplex,

and,

optimizing the network by dynamically adapting the diversity channels between nodes of said transmitting and receiving subsets.

42. (original) A method as in claim 41, wherein said a transmission/reception switch further comprises:

an element for tone and slot interleaving.

43. (original) A method as in claim 41, wherein said TMC codec and SOVA decoder are replaced with a Turbo codec.

44. (original) A method as in claim 1, wherein the step of dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

optimizing at each node acting as a receiver the receive weights using the MMSE technique to adjust the multitone transmissions between it and other nodes.

720 45. (original) A method as in claim 1, wherein the step of dynamically adapting the
721 diversity channels and said proper subsets to optimize said network further comprises:

722
723 optimizing at each node acting as a receiver the receive weights using the MAX
724 SINR to adjust the multitone transmissions between it and other nodes.

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726
727 46. (original) A method as in claim 1, wherein the step of dynamically adapting the
728 diversity channels and said proper subsets to optimize said network further comprises:

729
730 optimizing at each node acting as a receiver the receive weights, then optimizing
731 the transmit weights at that node by making them proportional to the receive
732 weights, and then optimizing the transmit gains for that node by a max-min
733 criterion for the link capacities for that node at that particular time.

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736 47. (original) A method as in claim 1, wherein the step of dynamically adapting the
737 diversity channels and said proper subsets to optimize said network further comprises:

738
739 including, as part of said network, one or more network controller elements that
740 assist in tuning local node's maximum capacity criteria and link channel diversity
741 usage to network constraints.

742
743
744 48. (original) A method as in claim 1, wherein the step of dynamically adapting the
745 diversity channels and said proper subsets to optimize said network further comprises:

characterizing the channel response vector $\mathbf{a}_1(f, t; n_2, n_1)$ by the observed

(possibly time-varying) azimuth and elevation $\{\theta_1(t; n_2, n_1),$

$\varphi_1(f, t; n_2, n_1)\}$ of node n_2 observed at n_1 .

49. (original) A method as in claim 1, wherein the step of dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

characterizing the channel response vector $\mathbf{a}_1(f, t; n_2, n_1)$ as a superposition of direct-path and near-field reflection path channel responses, e.g., due to scatterers in the vicinity of n_1 , such that each element of $\mathbf{a}_1(f, t; n_2, n_1)$ can be modeled as a random process, possibly varying over time and frequency.

50. (original) A method as in claim 1, wherein the step of dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

presuming that $\mathbf{a}_1(f, t; n_2, n_1)$ and $\mathbf{a}_1(f, t; n_2, n_1)$ can be substantively time invariant over significant time durations, e.g., large numbers of OFDM symbols or TDMA time frames, and inducing the most significant frequency and time variation by the observed timing and carrier offset on each link.

51. (original) A method as in claim 1, wherein the step of dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

in such networks, e.g., TDD networks, wherein the transmit and receive frequencies are identical ($f_{21}(k) = f_{12}(k) = f(k)$) and the transmit and

receive time slots are separated by short time intervals ($t_{21}(l) = t_{12}(l) + \Delta_{21}$
 $\approx t(l)$), and $\mathbf{H}_{21}(k, l)$ and $\mathbf{H}_{21}(k, l)$ become substantively reciprocal,
 such that the subarrays comprising $\mathbf{H}_{21}(k, l)$ and $\mathbf{H}_{21}(k, l)$ satisfy $\mathbf{H}_{21}(k, l$
 $; n_2, n_1) \approx \delta_{21}(k, l; n_1, n_2) \mathbf{H}_{12}^T(k, l; n_1, n_2)$, where $\delta_{21}(k, l$
 $; n_1, n_2)$ is a unit-magnitude, generally nonreciprocal scalar, equalizing the
 observed timing offsets, carrier offsets, and phase offsets, such that $\lambda_{21}(n_2, n_1)$
 $\approx \lambda_{12}(n_1, n_2)$, $\tau_{21}(n_2, n_1) \approx \tau_{12}(n_2, n_1)$, and $\nu_{21}(n_1, n_2) \approx \nu_{12}$
 (n_2, n_1) , by synchronizing each node to an external, universal time and
 frequency standard, obtaining $\delta_{21}(k, l; n_1, n_2) \approx 1$, and establishing
 network channel response as truly reciprocal $\mathbf{H}_{21}(k, l) \approx \mathbf{H}_{21}^T(k, l)$.

52. A method as in claim 51, wherein the synchronization of each node is to Global
 Position System Universal Time Coordinates (GPS UTC).

53. (original) A method as in claim 51, wherein the synchronization of each node is to a
 network timing signal.

54. (original) A method as in claim 51, wherein the synchronization of each node is to a
 combination of Global Position System Universal Time Coordinates (GPS UTC) and a
 network timing signal.

55. (original) A method as in claim 1, wherein the step of dynamically adapting the
 diversity channels and said proper subsets to optimize said network further comprises:

for such parts of the network where the internode channel responses possess substantive multipath, such that $\mathbf{H}_{21}(k, l; n_2, n_1)$ and $\mathbf{H}_{21}(k, l; n_2, n_1)$ have rank greater than unity, making the channel response substantively reciprocal by:

(1) forming uplink and downlink transmit signals using the matrix formula in EQ. 40;

(2) reconstructing the data intended for each receive node using the matrix formula in EQ. 41;

(3) developing combiner weights that $\{\mathbf{w}_1(k, l; n_2, n_1)\}$ and $\{\mathbf{w}_2(k, l; n_1, n_2)\}$ that substantively null data intended for recipients during the symbol recovery operation, such that for $n_1 \neq n_2$:

(4) developing distribution weights $\{\mathbf{g}_1(k, l; n_2, n_1)\}$ and $\{\mathbf{g}_2(k, l; n_1, n_2)\}$ that perform equivalent substantive nulling operations during transmit signal formation operations;

(5) scaling distribution weights to optimize network capacity and/or power criteria, as appropriate for the specific node topology and application addressed by the network;

(6) removing residual timing and carrier offset remaining after recovery of the intended network data symbols;

and

(7) encoding data onto symbol vectors based on the end-to-end SINR obtainable between each transmit and intended recipient node, and decoding that data after symbol recovery operations, using channel coding and decoding methods develop in prior art.

56. (original) A method as in claim 1, wherein dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

forming substantively nulling combiner weights using an FFT-based least-squares algorithms that adapt $\{\mathbf{w}_1(k, l; n_2, n_1)\}$ and $\{\mathbf{w}_2(k, l; n_1, n_2)\}$ to values that minimize the mean-square error (MSE) between the combiner output data and a known segment of transmitted pilot data;

applying the pilot data to an entire OFDM symbol at the start of an adaptation frame comprising a single OFDM symbol containing pilot data followed by a stream of OFDM symbols containing information data;

wherein the pilot data transmitted over the pilot symbol is preferably given by EQ. 44 and EQ. 45, such that the “pseudodelays” $\delta_1(n_1)$ and $\delta_2(n_2)$ are unique to each transmit node (in small networks), or provisioned at the beginning of communication with any given recipient node (in which case each will be a function of n_1 and n_2), giving each pilot symbol a pseudorandom component;

maintaining minimum spacing between any pseudodelays used to communicate with a given recipient node that is larger than the maximum expected timing offset observed at that recipient node, said spacing should also being an integer multiple of $1/K$, where K is the number of tones used in a single FFT-based LS algorithm;

and if K is not large enough to provide a sufficiency of pseudodelays, using additional OFDM symbols for transmission of pilot symbols, either lengthening the effective value of K , or reducing the maximum number of originating nodes transmitting pilot symbols over the same OFDM symbol;

also providing K large enough to allow effective combiner weights to be constructed from the pilot symbols alone;

then obtaining the remaining information-bearing symbols, which are the uplink and downlink data symbols provided by prior encoding, encryption, symbol randomization, and channel preemphasis stages, in the adaptation frame, by EQ. 46 and EQ. 47;

removing at the recipient node, first the pseudorandom pilot components from the received data by multiplying each tone and symbol by the pseudorandom components of the pilot signals, using EQ. 47 and EQ. 48;

thereby transforming each authorized and intended pilot symbol for the recipient node into a complex sinusoid with a slope proportional to the sum of the pseudodelay used during the pilot generation procedure, and the actual observed timing offset for that link, and leaving other, unauthorized pilot symbols, and symbols intended for other nodes in the network, untransformed and so appearing as random noise at the recipient node.

57. (original) A method as in claim 55, wherein the FFT-Least Squares algorithm is that shown in Figure 37.

58. (original) A method as in claim 55, wherein the pseudodelay estimation is refined using a Gauss-Newton recursion using the approximation :

$$\exp\{-j2\pi\Delta(k-k_0)/PK\} \approx 1 -j2\pi\Delta(k-k_0)/PK.$$

59. (original) A method as in claim 1, wherein wherein dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

using the linear combiner weights provided during receive operations are construct linear distribution weights during subsequent transmit operations, by setting distribution weight $\mathbf{g}_1(k, l; n_2, n_1)$ proportional to $\mathbf{w}_1^*(k, l; n_2, n_1)$ during uplink transmit operations, and $\mathbf{g}_2(k, l; n_1, n_2)$ proportional to $\mathbf{w}_2^*(k, l; n_1, n_2)$ during downlink transmit operations; thereby making the transmit weights substantively nulling and thereby allowing each node to form frequency and time coincident two-way links to every node in its field of view, with which it is authorized (through establishment of link set and transfer of network/recipient node information) to communicate.

60. (original) A method as in claim 1, wherein each node in the first subset of nodes further comprises:

a LEGO implementation element and algorithm.

61. (original) A method as in claim 1, wherein dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

balancing the power use against capacity for each channel, link, and node, and hence for the network as a whole by:

establishing a capacity objective B for a particular Node 2 receiving from another Node 1 as the target to be achieved by node 2 solving, at Node 2 the local optimization problem:

$$\min \sum_q \pi_1(q) \equiv \mathbf{1}^T \boldsymbol{\pi}_1, \text{ such that}$$

$$\sum_{q \in Q(m)} \log(1 + \gamma(q)) \geq \beta(m),$$

where $\pi_1(q)$ is the SU (user 1 node) transmit power for link number q ,

$\gamma(q)$ is the signal to interference noise ratio (SINR) seen at the output of the beamformer,

$\mathbf{1}$ is a vector of all 1s,

and

$\boldsymbol{\pi}_1$ is a vector whose q^{th} element is $p_1(q)$,

the aggregate set $Q(m)$ contains a set of links that are grouped together for the purpose of measuring capacity flows through those links;

using at Node 2 the local optimization solution to moderate the transmit and receive weights, and signal information, returned to node 1;

and,

using said feedback to compare against the capacity objective B and incrementally adjust the transmit power at each of Node 1 and Node 2 until no further improvement is perceptible.

62. (original) A method as in claim 1, wherein dynamically adapting the diversity channels and said proper subsets to optimize said network further comprises:

using the downlink objective function in EQ. 5 and EQ. 6 at each node to perform local optimization;

reporting the required feasibility condition, $\sum_{q \in Q(m)} \pi_1(q) \leq R_1(m)$;

and,

modifying $\beta(m)$ as necessary to stay within the constraint.

63. (original) A method as in claim 60[61], wherein:

the capacity constraints $\beta(m)$ are determined in advance for each proper subset of nodes, based on known QoS requirements for each said proper subset.

64. (original) A method as in claim 60[61], wherein said network further seeks to minimize total power in the network as suggested by EQ. 4.

65. (original) A method as in claim 60[61], wherein said network sets as a target objective for the network \mathbf{B} the QoS for the network.

66. (original) A method as in claim 60[61], wherein said network sets as a target objective for the network \mathbf{B} a vector of constraints.

67. (original) A method as in claim 60[61], wherein the local optimization problem is further defined such that:

the receive and transmit weights are unit normalized with respect to the background interference autocorrelation matrix;

the local SINR is expressed as EQ. 8;

and the weight normalization in EQ. 6 is used to enable the reciprocity equation at that node, thereby allowing the uplink and downlink function to be presumed identical rather than separately computed.

68. (original) A method as in claim 60[61], wherein:

very weak constraints to the transmit powers are approximated by using a very simple approximation for $\gamma(q)$.

69. (original) A method as in claim 60[61], for the cases wherein all the aggregate sets contain a single link and non-negligible environmental noise is present, wherein the transmit powers are computed as Perron vectors from EQ. 10, and a simple power constraint is imposed upon the transmit powers.

70. (original) A method as in claim 60[69], wherein the optimization is performed in alternating directions and repeated.

71. (original) A method as in claim 60[61], wherein each node presumes the post-beamforming interference energy remains constant for the adjustment interval and so solves EQ. 3 using classic water filling arguments based on Lagrange multipliers, and then uses a similar equation for the reciprocal element of the link.

72. (original) A method as in claim 60[61], wherein at each node the constrained optimization problem stated in EQ. 13 and 14 is solved using the approximation in EQ. 11, and the network further comprises at least one high-level network controller that

985 controls the power constraints $R_1(q)$, and drives the network towards a max-min
986 solution.

987

988 73. (original) A method as in claim 60[61], wherein each node:

989

990 is given an initial γ_0 ;

991 generates the model expressed in EQ. 20, EQ. 21, and EQ. 22;

992 updates the new γ_α from EQ. 23 and EQ. 24;

993 determines a target SINR to adapt to;

994 and,

995 updates the transmit power for each link q according to EQ. 25 and EQ. 26.

996

997

998 74. (original) A method as in claim 60[61], for each node wherein the transmit power
999 relationship of EQ. 25 and EQ 26 is not known, that:

1000

1001 uses a suitably long block of N samples is used to establish the relationship, where

1002 N is either 4 times the number of antennae or 128, whichever is larger;

1003 uses the result to update the receive weights at each end of the link;

1004 optimizes the local model as in EQ. 23 and EQ. 24;

1005 and then applies EQ. 25 and EQ. 26.

1006

1007

1008 75. (original) A method as in claim 60[61] that, for an aggregate proper subset m :

1009

1010 for each node within the set m , inherits the network objective function model
1011 given in EQ. 28, EQ. 29, and EQ. 30;

1012 eliminates the step of matrix channel estimation, transmitting instead from

1013 that node as a single real number for each link to the other end of said link

1014 an estimate of the post beamforming interference power;

1015 and ,
1016 receives back for each link a single real number being the transmit power.
1017
1018 76. (original) A method as in claim 75, that for each pair of nodes assigns to the one
1019 presently possessing the most processing capability the power management
1020 computations.
1021
1022 77. (original) A method as in claim 74[75] that estimates the transfer gains and the post
1023 beamforming interference power using simple least squares estimation techniques.
1024
1025 78. (original) A method as in claim 74[75]that, for estimating the transfer gains and post
1026 beamforming interference power:
1027
1028 instead solves for the transfer gain h using EQ. 31;
1029 uses a block of N samples of data to estimate h using EQ. 32;
1030 obtains an estimation of residual interference power R_e using EQ. 33;
1031 and,
1032 obtains knowledge of the transmitted data symbols $S(n)$ from using
1033 remodulated symbols at the output of the codec.
1034
1035 79. (original) A method as in claim 77 [78] wherein, instead of obtaining knowledge of
1036 the transmitted data symbols $S(n)$ from using remodulated symbols at the output of the
1037 codec, the node uses the output of a property restoral algorithm used in a blind
1038 beamforming algorithm.
1039
1040 80. (original) A method as in claim 77 [78] wherein, instead of obtaining knowledge of
1041 the transmitted data symbols $S(n)$ from using remodulated symbols at the output of the
1042 codec, the node uses a training sequence explicitly transmitted to train beamforming
1043 weights and asset the power management algorithms.

- 1044
- 1045 81. (original) A method as in claim 77 [78] wherein, instead of obtaining knowledge of
- 1046 the transmitted data symbols $S(n)$ from using remodulated symbols at the output of the
- 1047 codec, the node uses any combination of:
- 1048 the output of a property restoral algorithm used in a blind beamforming algorithm;
- 1049 a training sequence explicitly transmitted to train beamforming weights and asset
- 1050 the power management algorithms;
- 1051 or,
- 1052 other means known to the art.
- 1053
- 1054 82. (original) A method as in claim 60[61], wherein each node incorporates a link level
- 1055 optimizer and a decision algorithm, as illustrated in Figure 32A and 32B.
- 1056
- 1057 83. (original) A method as in claim 81[82], wherein the decision algorithm is a
- 1058 Lagrange multiplier technique.
- 1059
- 1060 84. (original) A method as in claim 60[61], wherein the solution to EQ. 3 is
- 1061 implemented by a penalty function technique.
- 1062
- 1063 85. (original) A method as in claim 83[84], wherein the penalty function technique:
- 1064 takes the derivative of $\gamma(q)$ with respect to π_1 ;
- 1065 and,
- 1066 uses the Kronecker-Delta function and the weighted background noise.
- 1067
- 1068 86. (original) A method as in claim 83[84], wherein the penalty function technique
- 1069 neglects the noise term.
- 1070
- 1071 87. (original) A method as in claim 83[84], wherein the penalty function technique
- 1072 normalizes the noise term to one.
- 1073

1074 88. (original) A method as in claim 60[61], wherein the approximation uses the receive
1075 weights.
1076

1077 89. (original) A method as in claim 60[61], wherein adaptation to the target objective is
1078 performed in a series of measured and quantized descent and ascent steps.
1079

1080 90. (original) A method as in claim 60[61], wherein the adaptation to the target
1081 objective is performed in response to information stating the vector of change.
1082

1083 91. (original) A method as in claim 60[61], which uses the log linear mode in EQ. 34
1084 and the inequality characterization in EQ. 35 to solve the approximation problem with a
1085 simple low dimensional linear program.
1086

1087 92. (original) A method as in claim 60[61], develops the local mode by matching
1088 function values and gradients between the current model and the actual function.
1089

1090 93. (original) A method as in claim 60[61], which develops the model as a solution to
1091 the least squares fit, evaluated over several points.
1092

1093 94. (original) A method as in claim 60[61], which reduces the cross-coupling effect by
1094 allowing only a subset of links to update at any one particular time, wherein the subset
1095 members are chosen as those which are more likely to be isolated from one another.
1096

1097 95. (original) A method as in claim 60[61], wherein:
1098 the network further comprises a network controller element;
1099 said network controller element governs a subset of the network;
1100 said network controller element initiates, monitors, and changes the target
1101 objective for that subset;
1102 said network controller communicates the target objective to each node in that
1103 subset;
1104 and,

1105 receives information from each node concerning the adaptation necessary to meet
 1106 said target objective.
 1107
 1108 96. (original) A method as in claim 94[95], wherein said network further records the
 1109 scalar and history of the increments and decrements ordered by the network controller.
 1110
 1111 97. (original) A method as in claim 60[61], wherein for any subset, a target objective
 1112 may be a power constraint.
 1113
 1114 98. (original) A method as in claim 60[61], wherein for any subset, a target objective
 1115 may be a capacity maximization subject to a power constraint.
 1116
 1117 99. (original) A method as in claim 60[61], wherein for any subset, a target objective
 1118 may be a power minimization subject to the capacity attainment to the limit possible over
 1119 the entire network.
 1120
 1121 100. (original) A method as in claim 60[61], wherein for any subset, a target objective
 1122 may be a power minimization at each particular node in the network subject to the
 1123 capacity constraint at that particular node.
 1124
 1125
 1126 101. (original) A wireless electromagnetic communications network, comprising:
 1127
 1128 a wireless electromagnetic communications network, comprising
 1129
 1130 a set of nodes, said set further comprising,
 1131
 1132 at least a first subset wherein each node is MIMO-capable,
 1133 comprising:
 1134 a spatially diverse antennae array of M antennae, where M
 1135 \geq one,

1136 a transceiver for each antenna in said array,
1137 means for digital signal processing,
1138 means for coding and decoding data and symbols,
1139 means for diversity transmission and reception,
1140 and,
1141 means for input and output from and to a non-radio
1142 interface;
1143
1144 said set of nodes further comprising one or more proper subsets of nodes,
1145 being at least one transmitting and at least one receiving subset, with said
1146 transmitting and receiving subsets having a topological arrangement
1147 whereby:
1148
1149 each node in a transmitting subset has no more nodes with which it
1150 will simultaneously communicate in its field of view, than it has
1151 number of antennae;
1152
1153 each node in a receiving subset has no more nodes with which it
1154 will simultaneously communicate in its field of view, than it can
1155 steer independent nulls to;
1156 and,
1157 each member of a non-proper subset cannot communicate with any
1158 other member of its non-proper subset;
1159
1160 transmitting independent information from each node in a first non-proper subset
1161 to one or more receiving nodes belonging to a second non-proper subset that are
1162 viewable from the transmitting node;
1163
1164 processing independently information transmitted to a receiving node in a second
1165 non-proper subset from one or more nodes in a first non-proper subset is
1166 independently by the receiving node;

1167 and,
1168 optimizing the network by dynamically adapting the diversity channels between nodes of
1169 said transmitting and receiving subsets.
1170
1171
1172 102. (original) An apparatus as in claim ~~100~~[101], further comprising an element
1173 for scheduling according to a Demand-Assigned, Multiple-Access algorithm.
1174
1175 103. (original) An apparatus as in claim ~~100~~[101], further comprising for each
1176 node in said first subset a LEGO adaptation element.
1177
1178 104. (original) An apparatus as in claim ~~100~~[101], further comprising:
1179
1180 for each node in said first subset a LEGO adaptation element; and,
1181 one or more network controllers.
1182
1183 105. (original) A method as in claim 1, wherein the step of dynamically adapting
1184 the diversity channels and said proper subsets to optimize said network further comprises:
1185
1186 matching each transceiver's degrees of freedom (DOF) to the nodes in the
1187 possible link directions;
1188 equalizing those links to provide node-equivalent uplink and downlink capacity.
1189
1190 106. (original) A method as in claim 105, further comprising, after the DOF matching:
1191
1192 assigning asymmetric transceivers to reflect desired capacity weighting;
1193 adapting the receive weights to form a solution for multipath resolutions;
1194 employing data and interference whitening as appropriate to the local conditions;
1195 and,
1196 using retrodirective transmission gains during subsequent transmission operations.
1197

1198 107. (original) A method as in claim 105, wherein the receive weights are similarly
1199 modified.
1200
1201
1202
1203 108. (currently amended) A method for optimizing a wireless electromagnetic
1204 communications network, comprising:
1205
1206 a wireless electromagnetic communications network, comprising
1207
1208 a set of nodes, said set of nodes further comprising,
1209
1210 at least a first subset wherein each node is MIMO-capable,
1211 comprising:
1212 an antennae array of M antennae, where $M \geq$ one,
1213 a transceiver for each antenna in said spatially diverse
1214 antennae array,
1215 means for digital signal processing to convert analog radio
1216 signals into digital signals and digital signals into analog
1217 radio signals,
1218 means for coding and decoding data, symbols, and control
1219 information into and from digital signals,
1220 diversity capability means for transmission and reception of
1221 said analog radio waves [signals];
1222 and,
1223 means for input and output from and to a non-radio
1224 interface for digital signals;
1225
1226 said set of nodes being deployed according to design rules that prefer
1227 meeting the following criteria:
1228

1229 said set of nodes further comprising two or more proper subsets of
1230 nodes, with a first proper subset being the transmit uplink / receive
1231 downlink set, and a second proper subset being the transmit
1232 downlink / receive uplink set;
1233
1234 each node in said set of nodes belonging to no more transmitting
1235 uplink or receiving uplink subsets than it has diversity capability
1236 means;
1237
1238 each node in a transmit uplink / receive downlink subset has no
1239 more nodes with which it will hold time and frequency coincident
1240 communications in its field of view, than it has diversity
1241 capability;
1242
1243 each node in a transmit downlink / receive uplink subset has no
1244 more nodes with which it will hold time and frequency coincident
1245 communications in its field of view, than it has diversity
1246 capability;
1247
1248 each member of a transmit uplink / receive downlink subset cannot
1249 hold time and frequency coincident communications with any
1250 other member of that transmit uplink / receive downlink subset;
1251 and,
1252 each member of a transmit downlink / receive uplink subset cannot
1253 hold time and frequency coincident communications with any
1254 other member of that transmit downlink / receive uplink subset;
1255
1256 transmitting, in said wireless electromagnetic communications network,
1257 independent information from each node belonging to a first proper subset, to one
1258 or more receiving nodes belonging to a second proper subset that are viewable
1259 from the transmitting node;

processing independently, in said wireless electromagnetic communications network, at each receiving node belonging to said second proper subset, information transmitted from one or more nodes belonging to said first proper subset;

optimizing at the local level for each node for the channel capacity D_{21} according to EQ. 49, solving first the reverse link power control problem; then treating the forward link problem in an identical fashion, substituting the subscripts 2 for 1 in said equation;
and,
dynamically adapting the diversity channels and said proper subsets to optimize said network.

109. (original) A method as in claim 108, further comprising:

for each aggregate subset m , attempting to achieve the given capacity objective, β , as described in EQ. 50, by:

(1) optimizing the receive beamformers, using simple MMSE processing, to simultaneously optimize the SINR;

(2) based on the individual measured SINR for each q index, attempt to incrementally increase or lower its capacity as needed to match the current target;
and,

(3) stepping the power by a quantized small step in the appropriate direction;

then,

when all aggregate sets have achieved the current target capacity, then the network can either increase the target capacity β , or add additional users to exploit the now-known excess capacity.

1290 110. (original) A method as in claim 106[107], wherein instead of optimizing for
1291 channel capacity, the network optimizes for QoS.
1292

1293 111. (original) A method as in claim 94[95], wherein:
1294
1295 said network controller adds, drops, or changes the target capacity for any node in
1296 the set the network controller controls.
1297

1298 112. (original) A method as in claim 94[95], wherein:
1299
1300 said network controller may, either in addition to or in replacement for altering β ,
1301 add, drop, or change channels between nodes, frequencies, coding, security, or
1302 protocols, polarizations, or traffic density allocations usable by a particular node
1303 or channel.
1304
1305

1306 113. (original) A wireless electromagnetic communications network, comprising:
1307
1308 a set of nodes, said set further comprising,
1309 at least a first subset wherein each node is MIMO-capable,
1310 comprising:
1311 a spatially diverse antennae array of M antennae, where M
1312 \geq one,
1313 a transceiver for each antenna in said array,
1314 13 means for digital signal processing,
1315 14 means for coding and decoding data and symbols,
1316 19 means for diversity transmission and reception,
1317 pilot symbol coding & decoding element
1318 timing synchronization element
1319 and,

1320 means for input and output from and to a non-radio
1321 interface;
1322
1323 said set of nodes further comprising two or more proper subsets of nodes,
1324 there being at least one transmitting and at least one receiving subset, with
1325 said transmitting and receiving subsets subset having a diversity
1326 arrangement whereby:
1327
1328 each node in a transmitting subset has no more nodes with which it
1329 will simultaneously communicate in its field of view, than it has
1330 number of antennae;
1331
1332 each node in a receiving subset has no more nodes with which it
1333 will simultaneously communicate in its field of view, than it can
1334 steer independent nulls to;
1335 and,
1336 each member of a non-proper subset cannot communicate with any
1337 other member of its non-proper subset over identical diversity
1338 channels;
1339
1340 a LEGO adaptation element and algorithm;
1341
1342 a network controller element and algorithm;
1343
1344 whereby each node in a first non-proper subset transmits independent information
1345 to one or more receiving nodes belonging to a second non-proper subset that are
1346 viewable from the transmitting node;
1347
1348 each receiving node in said second non-proper subset processes independently
1349 information transmitted to a from one or more nodes in a first non-proper subset is
1350 independently by the receiving node;

1351

1352

each node uses means to minimize SINR between nodes transmitting and receiving information;

1353

1354

1355

the network is designed such that substantially reciprocal symmetry exists for the uplink and downlink channels by,

1356

1357

1358

if the received interference is spatially white in both link directions, setting

1359

1360

$g_1(a) \propto w_2^* q$ and $g_2(q) \propto w_1^*(q)$ at both ends of the link,

1361

where $\{g_2(q), w_1(q)\}$ are the linear transmit and receive weights used in the downlink;

1362

1363

1364

but if the received interference is not spatially white in both link

1365

directions, constraining $\{g_1(q)\}$ and $\{g_2(q)\}$ to satisfy:

1366

1367

Q_{21}

1368

$$\sum_{q=1}^{Q_{21}} g_1^T(q) R_{i1i1} [n_1(q)] g_1^*(q) =$$

1369

$q = 1$

1370

N_1

1371

$$\sum_{n=1}^{N_1} \text{Tr}\{R_{i1i1}(n)\} = M_1 R_1;$$

1372

$n=1$

1373

1374

Q_{12}

1375

$$\sum_{q=1}^{Q_{12}} g_2^T(q) R_{i2i2} [n_2(q)] g_2^*(q) =$$

1376

$q = 1$

1377

$n=1$

1378
$$\sum_{N_2} \text{Tr}\{R_{i_2 i_2}(n)\} = M_2 R_2,$$

1379
$$N_2$$

1380

1381

1382 the network uses any standard communications protocol;

1383

1384 and,

1385

1386 the network is optimized by dynamically adapting the diversity channels between
1387 nodes of said transmitting and receiving subsets.

1388

1389

1390 114. (original) A wireless electromagnetic communications network as in claim

1391 ~~442~~[113]:

1392 wherein each node may further comprise a Butler Mode Forming element, to
1393 enable said node to ratchet the number of active antennae for a particular uplink
1394 or downlink operation up or down.

1395

1396

1397 115. (original) A wireless electromagnetic communications network as in claim 50:

1398 incorporating a dynamics-resistant multitone element.

1399

1400

1401 116. (original) The use of a method as described in claim 1 for fixed wireless

1402 electromagnetic communications.

1403

1404 117. (original) The use of an apparatus as described in claim 50 for fixed wireless

1405 electromagnetic communications.

1406

1407 118. (original) The use of a method as described in claim 1 for mobile wireless
1408 electromagnetic communications.
1409
1410 119. (original) The use of an apparatus as described in claim 50 for mobile wireless
1411 electromagnetic communications.
1412
1413 120. (original) The use of a method as described in claim 1 for mapping operations using
1414 wireless electromagnetic communications.
1415
1416 121. (original) The use of an apparatus as described in claim 50 for mapping operations
1417 using wireless electromagnetic communications.
1418
1419 122. (original) The use of a method as described in claim 1 for a military wireless
1420 electromagnetic communications network.
1421
1422 123. (original) The use of an apparatus as described in claim 50 for a military wireless
1423 electromagnetic communications network.
1424
1425 124. (original) The use of a method as described in claim 1 for a military wireless
1426 electromagnetic communications network for battlefield operations.
1427
1428 125. (original) The use of an apparatus as described in claim 50 for a military wireless
1429 electromagnetic communications network for battlefield operations.
1430
1431 126. (original) The use of a method as described in claim 1 for a military wireless
1432 electromagnetic communications network for Back Edge of Battle Area (BEBA)
1433 operations.
1434
1435 127. (original) The use of an apparatus as described in claim 50 for a military wireless
1436 electromagnetic communications network for Back Edge of Battle Area (BEBA)
1437 operations..

1438

1439 128. (original) The use of a method as described in claim 1 for a wireless electromagnetic
1440 communications network for intruder detection operations.

1441

1442 129. (original) The use of an apparatus as described in claim 50 for a wireless
1443 electromagnetic communications network for intruder detection operations..

1444

1445 130. (original) The use of a method as described in claim 1 for a wireless electromagnetic
1446 communications network for logistical intercommunications.

1447

1448 131. (original) The use of an apparatus as described in claim 50 for a wireless
1449 electromagnetic communications network for logistical intercommunications.

1450

1451 132. (original) The use of a method as described in claim 1 in a wireless electromagnetic
1452 communications network for self-filtering spoofing signals.

1453

1454 133. (original) The use of an apparatus as described in claim 50 for a wireless
1455 electromagnetic communications network for self-filtering spoofing signals..

1456

1457 134. (original) The use of a method as described in claim 1 in a wireless
1458 electromagnetic communications network for airborne relay over the horizon.

1459

1460 135. (original) The use of an apparatus as described in claim 50 for a wireless
1461 electromagnetic communications network for airborne relay over the horizon.

1462

1463 136. (original) The use of a method as described in claim 1 in a wireless electromagnetic
1464 communications network for traffic control.

1465

1466 137. (original) The use of a method as in claim 136[1], further comprising the use thereof
1467 for air traffic control

1468

1469 138. (original) The use of a method as in claim ~~466~~[1], further comprising the use
1470 thereof for ground traffic control.
1471

1472 139. (original) The use of a method as in claim ~~466~~[1], further comprising the use
1473 thereof for a mixture of ground and air traffic control.
1474

1475 140. (original) The use of an apparatus as described in claim 50 for a wireless
1476 electromagnetic communications network for traffic control.
1477

1478 141. (original) The use of an apparatus as in claim ~~470~~[50], further comprising the use
1479 thereof for air traffic control
1480

1481 142. (original) The use of an apparatus as in claim ~~470~~[50], further comprising the use
1482 thereof for ground traffic control.
1483

1484 143. (original) The use of an apparatus as in claim ~~470~~[50], further comprising the use
1485 thereof for a mixture of ground and air traffic control.
1486

1487 144. (original) The use of a method as in claim 1 in a wireless electromagnetic
1488 communications network for emergency services.
1489

1490 145. (original) The use of an apparatus as in claim 50 in a wireless electromagnetic
1491 communications network for emergency services.
1492

1493 146. (original) The use of a method as in claim 1 in a wireless electromagnetic
1494 communications network for shared emergency communications without interference.
1495

1496 147. (original) The use of an apparatus as in claim 50 in a wireless electromagnetic
1497 communications network for shared emergency communications without interference.
1498

1499 148. (original) The use of a method as in claim 1 in a wireless electromagnetic
1500 communications network for positioning operations without interference.
1501

1502 149. (original) The use of an apparatus as in claim 50 in a wireless electromagnetic
1503 communications network for positioning operations without interference.
1504

1505 150. (original) The use of a method as in claim 1 in a wireless electromagnetic
1506 communications network for high reliability networks requiring graceful degradation
1507 despite environmental conditions or changes..
1508

1509 151. (original) The use of an apparatus as in claim 50 in a wireless electromagnetic
1510 communications network for high reliability networks requiring graceful degradation
1511 despite environmental conditions or changes..
1512

1513 152. (original) The use of a method as in claim 1 in a wireless electromagnetic
1514 communications network for a secure network requiring assurance against unauthorized
1515 intrusion.
1516

1517 153. (original) The use of a method as in claim 1 in a wireless electromagnetic
1518 communications network for a secure network requiring message end-point assurance.
1519

1520 154. (original) The use of a method as in claim 1 in a wireless electromagnetic
1521 communications network for a secure network requiring assurance against unauthorized
1522 intrusion and message end-point assurance.
1523

1524 155. (original) The use of an apparatus as in claim 50 in a wireless electromagnetic
1525 communications network for a secure network requiring assurance against unauthorized
1526 intrusion.
1527

1528 156. (original) The use of an apparatus as in claim 50 in a wireless electromagnetic
1529 communications network for a secure network requiring message end-point assurance.

1530

1531 157. (original) The use of an apparatus as in claim 50 in a wireless electromagnetic
1532 communications network for a secure network requiring assurance against unauthorized
1533 intrusion and message end-point assurance.

1534

1535

1536 158. (original) The use of a method as in claim 1 in a cellular mobile radio service.

1537

1538 159. (original) The use of an apparatus as in claim 50 in a cellular mobile radio
1539 service.

1540

1541 160. (original) The use of a method as in claim 1 in a personal communication service.

1542

1543 161. (original) The use of an apparatus as in claim 50 in a personal communication
1544 service.

1545

1546 162. (original) The use of a method as in claim 1 in a private mobile radio service.

1547

1548 163. (original) The use of an apparatus as in claim 50 in a private mobile radio service.

1549

1550 164. (original) The use of a method as in claim 1 in a wireless LAN.

1551

1552 165. (original) The use of an apparatus as in claim 50 in a wireless LAN.

1553

1554 166. (original) The use of a method as in claim 1 in a fixed wireless access service.

1555

1556 167. (original) The use of an apparatus as in claim 50 in a fixed wireless access service.

1557

1558 168. (original) The use of a method as in claim 1 in a broadband wireless access service.

1559

1560 169. (original) The use of an apparatus as in claim 50 in a broadband wireless
1561 access service.
1562
1563 170. (original) The use of a method as in claim 1 in a municipal area network.
1564
1565 171. (original) The use of an apparatus as in claim 50 in a municipal area network.
1566
1567 172. (original) The use of a method as in claim 1 in a wide area network.
1568
1569 173. (original) The use of an apparatus as in claim 50 in a wide area network.
1570
1571 174. (original) The use of a method as in claim 1 in wireless backhaul.
1572
1573 175. (original) The use of an apparatus as in claim 50 in wireless backhaul.
1574
1575 176. (original) The use of a method as in claim 1 in wireless backhaul.
1576
1577 177. (original) The use of an apparatus as in claim 50 in wireless backhaul.
1578
1579 178. (original) The use of a method as in claim 1 in wireless SONET.
1580
1581 179. (original) The use of an apparatus as in claim 50 in wireless SONET.
1582
1583 180. (original) The use of a method as in claim 1 in wireless SONET.
1584
1585 181. (original) The use of an apparatus as in claim 50 in wireless SONET.
1586
1587 182. (original) The use of a method as in claim 1 in wireless Telematics.
1588
1589 183. (original) The use of an apparatus as in claim 50 in wireless Telematics.
1590